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## Microminerals in Nutrition

**Contents in in this issue**:

- "Microminerals in Nutrition."

The following is a transcription of the Third Quarter 1971 issue of Dr. Royal Lee's *Applied Trophology* newsletter, originally published by Standard Process Laboratories.

## Microminerals in Nutrition

### Essential for Metabolism

Previous to about 1940 little was known regarding the essentiality of minerals in nutrition. In fact, it was a much-neglected field of study or research. With the exception of calcium in bone formation, chlorine in hydrochloric acid production, iodine in thyroid activity, and the importance of iron in the formation of red blood cells, medical history is not very enlightening. This backwardness in the study of organic minerals has no doubt been due to the fact that, during this period, chemistry was in ascendency, and the majority of research was achieved by chemists. This is apparently the reason that medical textbooks considered all minerals as "inorganic" even after they had become integral parts of the living organism. We now know that from a physiological point of view, this premise was incorrect.

However, not being physiologists or modern biochemists, these early scientists were correct in that, chemically, these elements test the same, whether they are found in the air, earth, plant, or animal. It is the life process of the plant that changes the components of the air and soil into the live food that supplies our body with the vitalized force now known as electrolytes. Modern investigators can appreciate the disadvantages of the early scientist and the usual mineral chemical test of ashing, by intense heat, to determine the minerals present. It is quite obvious that, in testing organic matter for minerals by this method, the then unknown vital forces were destroyed.

Now, with modern methods for testing, we do not believe it justifiable to call mineral salts "inorganic" after they have become a vital physiological force in the living organism. Their availability in food entirely divorces them from comparison with such inorganic preparations as mined minerals or any other nonnutritive compound. These apparently lack the vital electrical energy and magnetism imparted to them by the organic combinations of the vegetable kingdom and fail to serve as catalysts.

### Catalysis

Although low in quantity, the minerals in our body are very high in importance. The organic minerals, and proteins also must be recognized as integral physiological parts of the living body and, in deficiency, are apparently just as subject to death as is the entire organism. Body cells are constantly being broken down and then rebuilt. Everything is involved in some way in this dynamic equilibrium. For example, proteins, among other things, also function as [*sic*] and mammalian life. This is in accordance with Liebig's Law of the Minimum, as development is controlled by the low nutrient, or the one in relative minimum.

### Macro and Microminerals

Only a few of the over one hundred known elements form the greater amount of organic matter in plants and animals. They are oxygen, carbon, hydrogen, nitrogen, and the mineral materials calcium, phosphorus, potassium, sodium, magnesium, chlorine, iron, and sulphur. Other important minerals rated essentially necessary to animal life, though present only in trace amounts, are cobalt, copper, iodine, manganese, molybdenum, zinc, selenium, chromium, and tin. Tin was added in 1970 through the research efforts of Dr. Klaus Schwartz, Professor of Medicine at University of California at Los Angeles. He had previously added selenium and chromium. Other minerals are also found in the body that may eventually prove to be necessary for good health. According to Dr. Schwartz, past methods of investigation were not quite sensitive enough.

### Essentiality

Not all the mineral elements present in plants and animals are essential for life. Even though present and exerting beneficial effects, some elements do not qualify as essential. Organisms can grow normally in the absence of some of these beneficial elements. Sodium and silicon are two such elements in plant life, and selenium, though fluorine and vanadium may be beneficial but not essential to mammals. However, the story on vanadium may change, with further research, as only recently it was found to play a part in mammalian blood formation.

To discover if an element is really essential to the growth and development of plants or animals, it must be studied in the absence of the mineral in question. If the results are death or abnormality, then this particular mineral is deemed to be essential. The resulting abnormality caused by the lack of an essential mineral is considered to be a true deficiency disease. Even though the nutrient in question is present, it may be useless, as the mammalian body, like the plants, has stringent rules in regard to the form in which the material must be presented for proper metabolism. For instance, the growth food milk contains a colloidal form of a calcium compound that is of a protein nature, which apparently explains the loss of assimilable calcium in pasteurized milk. Proteins are destroyed by heat much lower than the 145°F minimum required for pasteurization.

### Catalysts

The macro-elements are complex parts of biochemical reactions. They are present in large quantities (in comparison with the trace or microminerals), as they serve mainly as constituents of protein, cell-walls, or frame work structures. For instance, nitrogen as an integral part of all protein becomes a part of all enzyme systems by furnishing the body with all nitrogenous compounds necessary for maintenance and growth. Further, besides protein, all of the enzyme systems isolated to date have been found to contain an organic mineral and a vitamin working harmoniously. These serve as catalysts or catalytic agents, which in minute amounts can promote biochemical changes without themselves, as catalysts, being used up in the reactions. As the majority of these biochemical reactions are catalytic, evidently catalysts have a great influence on all microbes, plants and animals.

Early in 1929, Royal Lee, DDS, coined the word "catalyn" to represent the organic catalytic units found in natural food. Some twenty years later Professor Roger J. Williams of the University of Texas, an authority on nutrition, verified the authenticity of the word when he stated:

> "Natural food factors, or organic activating agents or enzymes and the microminerals, either singly or in combinations serve as biological catalysts. Units of body chemistry, regardless of their source or destination, are shuffled and reshuffled. In fact, it is presumed that in proper metabolism nothing remains static."

It is only recently that some of the minerals, as we have previously mentioned, were found to be essential to life. We believe that further investigation will reveal others essential to proper metabolism as catalysts, electrolytes, or possibly some new important physiological function not yet suspected. Rapid strides in new discoveries are being made through the use of isotopic techniques, the flame photometry method of estimating sodium and potassium, gas, and liquid chromatography, ultrasonic echoes from pulsed high-frequency soundwaves, and investigation of the possible role of the endocrine glands in water and electrolyte metabolism. Apparently, we are approaching the point where we may interpret many diseases from the biophysical level.

### Pure Water in Metabolism

From the earliest times, pure, fresh, drinking water has been recognized as an internal requirement, for inner and outer cleanliness and, therefore, indispensable to health and life. Water is also supplied through dietary liquids, solid foods, and by the oxidation of organic foodstuffs. The total body weight is about 70 percent water, with the volume of extracellular fluid comprising about 23 percent, and the plasma volume 5 percent of the total weight.

Just as the body requires balanced nutrition through amino acids, digestive juices, hormones, minerals, and vitamins, it also requires proper fluid balances for the osmotic exchange between its various parts and compartments. Good kidney action is also important in excreting or retaining and also maintaining the normal fluid level in the process of "ionic equilibrium."

Any interference with or aggravation of this vital process could be hazardous and promote further ill health. Such a disturbance has often been caused by diarrhea, polyuria, excessive sweating or vomiting. Clinically, any one of these conditions could interfere with mineral balance and require drinking an abnormal amount of water. It could very well further aggravate serious dehydration, especially so in chronic nephritis or the nephrotic syndrome with tubular lesions.

Each one of the many billions of cells in our body contain fluid and is surrounded by fluid, which certainly stresses the part of pure water in proper metabolism. As previously stated, "Body fluids carry the physical and chemical characteristics required in the cycle of life."

It is also an established fact that when osmotic equilibrium is disturbed, the viability and functional capacity of the body cells may be affected. We might add that at this time little is known of the long-term health effects of chemicalized water.

### Environmental Chemicals a Hazard

Of the thousands of chemicals, mostly as unsuspected additives that now adulterate our food, many are untested or, if tested, they have been tested one at a time on animals. Humans ingest many different chemicals each day. Any of them possibly in yet unheard-of combinations could probably interfere with proper metabolism. As Dr. Samuel S. Epstein, a scientist at Boston's Children's Cancer Research Foundation has stated, "There are probably many food additives, drugs and environmental agents which create harmful byproducts during their metabolism in the human body, although alone they are 'generally regarded as safe' (GRAS)."

The recent discovery in Norway of a liver condition caused by the interaction of nitrates (used as a preservative in sausage meats in this country), and amines such as cyclohexylamine, an organic compound naturally present in certain protein foods, combining to form nitrosamines. Nitrosamines are found to be capable of causing cancer in many organs and in all species of animals upon which they have been tested. In concentrates of only five parts per million they are capable of producing tumors, according to the report. As previously stated, nitrates also metabolize into nitrites, which kill off our much-needed intestinal bacteria.

Several years ago, the National Institutes of Health declared, "Chemicals may be as important as radiation in causing genetic damage. Chemicals in our food, air, and water may cause birth defects and mutations which can be passed on through generations."

Could this possibly have had a bearing on the 1966 edict of the FDA limiting the sale "by prescription only" of preparations containing added fluorine compounds for expectant mothers? Certain dentifrices were exempted. Apparently, we must regard all chemicals to be ingested with suspicion, specifically those known to be toxic, cumulative, or enzyme inhibitors.

Many of the food additives on the GRAS list are not even certified as safe for animals. The fact that they have been on the list for years does not make them safe. Of fifteen food dyes on the list tested for toxic, carcinogenic, or allergenic properties only one was conclusively shown to be harmless.

The recent clamor about the cyclamates and monosodium glutamate are new examples of a backward law requiring the FDA to prove they are not safe. The approximately 500 new chemicals added to the list yearly should be certified as safe before they make the list. As former FDA Commissioner Fleming asked, "Why should the consumer be the guinea pig?"

And, we add, why should the human body become the testing medium for industry's chemical refuse? The harm caused by chemicals may be slow and hard to detect as evidenced by the long-term safe-listed dyes, cyclamates, and MSG.

### Glandular Involvement

As previously stated, the metabolism of normal body function requires delicate balance, particularly enzymatic, hormonal, and osmotic balances. Although the kidneys are the most important organ in fluid and mineral balance, we also find that a supporting role in osmotic pressure is provided by the adrenal glands and the antidiuretic hormone (ADH) of the pituitary gland.

Another important physiological factor is the parathyroid hormone, which activates mobilization of calcium from the bones when it cannot be absorbed from the intestine. After the dissolution and resorption of ionized calcium from the skeleton, the liberated calcium enters the bloodstream. The calcium borrowed from the bones is repaid if and when a supply of assimilable calcium becomes available. The parathyroid hormone actually has a dual action in that it regulates the metabolism of both calcium and phosphorus as bone components.

### Calcium

Without doubt calcium is the most permanent thing in animal life. Calcium-bearing bones and teeth have been excavated intact after burial for thousands of years. In life we must meet nature's calciferous demands as bone and tooth cells continually break down. New calcium must be assimilated to replace them as well as calcium loss by excretion. When we consider that calcium makes up more than one-half of the entire mineral matter of the body, its importance in growth, development, and maintenance of all parts of the organism becomes quite apparent.

An adult man must assimilate a little over half a gram of calcium per day and a growing child or pregnant woman about twice as much. Some authorities believe the deficiency of calcium to be greater than that of other skeletal minerals; however, the deficiency of calcium and magnesium are often confused. Magnesium is the bone hardening mineral. It cooperates with calcium, phosphorus, iodine, silicon, sodium, and other organic material to form the skeleton.

Calcium must be dissolved in the acid medium of the stomach and then absorbed in the small intestine. It is then carried in the bloodstream to places of need, particularly the bones, teeth, muscles, and tissues of the body. In the bloodstream it is the activator of thrombin and other enzymes essential for blood clotting. Muscle deficiency of calcium in youngsters is often manifested by larygo-spasm (closure of the glottis) or, if more severe systemically, as rickets if vitamin D is also lacking.

In adults, deficiency in the early stage is manifested by muscular spasms (charley horses) or if more severe by convulsive seizures or tetany if magnesium and/or vitamin E is also systemically lacking. The amount of calcium absorbed is regulated by the body's need. Ten to fifty percent of the calcium eaten may be excreted in the feces.

The Golden Rule of foods in nutrition herein stated for calcium should be accepted for foods generally. The body is qualified to absorb a larger percentage of calcium from a low intake than from a more generous amount. Food sources of calcium are bone, dairy products, egg yolk, green leafy vegetables, beans, nuts, strawberries, oranges, lemons, figs, and grapes.

### Food vs. Drug Controversy

The basic food rule, as stated, must be considered in the presently disputed recommendations for vitamin C (ascorbic acid) and vitamin E (alpha tocopherol) as advocated by some medical practitioners. In this instance it is quite apparent that these vitamins ingested in such large amounts must be classified as drugs and can no longer be referred to as dietary supplements. As Dr. Royal Lee often stated, "Any time a food factor is consumed in quantities larger than the daily requirement it has become a drug and has lost its natural food value."

In other words, when food ceases to be food it also ceases to be a source of nutrition. We must conclude that in this instance, in all probability, ascorbic acid (vitamin C) and alpha tocopherol (vitamin E) are exerting a pharmacological or chemical rather than a physiological action.

Apparently, more study is needed to resolve this controversy. For, as Dr. Edwards, FDA Director, recently stated at a scientific meeting in Chicago, in complaining about the sad state of nutritional research, "We still don't know what the daily requirement for vitamin E should be and what does the requirement depend on...We still don't know whether vitamin C helps in the prevention of the common cold."

### Phosphorus

Animals and plants need phosphorus in the life processes of every cell. Normal adult humans should have a balanced amount of phosphorus and calcium. Children should have proportionately more. Phosphorus and calcium are the most important minerals in bone and tooth formation. In fact, the calcium-phosphorus combination comprises the largest amount of minerals in the body.

Phosphorus is required by some of the body lipids and proteins, namely the phospholipins and phosphatases. In the form of lecithin, it is essential to respiration and nerve impulse conduction and is therefore vitally linked with the thought processes. Good sources of phosphorus are much the same as for calcium, plus the fact that brain, liver, and cereals are high in phosphorus. In general, foods that contain calcium and proteins are usually good sources of phosphorus. Suggested also are meat, bone, egg yolk, bran, peas, beans, and peanuts. Very often an exclusive cereal diet unbalances the phosphorus-calcium ratio.

### Chlorine and Sodium

Few elements have the strong affinity for other elements that chlorine does. Cations of the blood, other than potassium and magnesium, are calcium and sodium; the anions include bicarbonate, chloride, protein, and small amounts of organic acids. In the blood the chlorides constitute about two-thirds of the anions. Clinically, it is noteworthy that any variation in the content of chlorides in the blood plasma is reflected in the chloride content of the cerebrospinal fluid. Sodium also forms a large amount of the total base of the blood plasma and is associated with bicarbonate and chloride ions and with them functions to maintain ionic equilibrium and osmotic pressure in the tissue and body fluids.

In 1956, Dr. W.H. Bergstrom reported that bone functions as an electrolyte reservoir and that skeletal sodium comprises 46 percent of total body sodium. It can be mobilized in the adult in response to various stimuli. Also, according to the National Academy of Sciences, sodium alone or in conjunction with other extracellular ions may play a role in the conduction of nerve impulses and the contractability of muscles.

The need for water and for sodium and chloride salts are closely related, although the excretory regulating mechanisms are not the same. About five grams of sodium chloride (table salt) daily is a liberal amount in most individuals and in ordinary occupations. Food sources of chlorine either as potassium or sodium chloride salts may be found in green leafy vegetables, radishes, carrots, dill, beets, cucumbers, strawberries, dried fruits, chicken, bile, spleen, lungs, sea fish, oysters, salmon, pike, beechnuts, almonds, filberts, and pecans. Rye is an exceptionally high source of chlorine.

### Iron

Iron deficiency in man is quite common and may result in anemia. We need iron in our blood to get oxygen from the air. Even though the body contains only enough iron to make a ten-penny nail, we could not have good red blood without it. The blood of all higher animals contains iron-bearing hemoglobin as the chief respiratory protein. In healthy people the liver stores all hemoglobin in excess of that needed by the blood.

Organic iron is also stored in the liver and in smaller amounts in the spleen, the intestinal mucosa, adrenals, and pancreas. Apparently, the hardworking muscles need a reserve supply of iron. As myoglobin it is stored in all muscle tissue and serves in the oxygenation of the muscles. Iron is present in many foods, but poor absorption by an alkaline gastrointestinal tract interferes with availability. A trace of copper must be present to make hemoglobin out of the available iron.

Clinically, the index of anemia is the hemoglobin content of the blood. However, iron deficiency anemia may, regardless of treatment, continue if copper is also deficient. Food sources of iron are liver, alfalfa, crude molasses, mushrooms, lettuce, dandelions, chives, cucumbers, horseradish, rye bran, walnuts, sorghum, dried fruit, potatoes, spinach, asparagus, and lean meat.

### Copper

Copper deficiency is associated particularly with degeneration of the nervous system, especially the inadequate myelination of the central nervous system. According to Steenbock, Elvehjem et al., minute amounts of copper have a stimulating effect on growth, respiration, and hematopoiesis. It apparently functions as the internal impulse or enzyme accelerator in the oxidation of iron.

Though small in amount, the daily intake of 2.0 to 2.5 mg is an absolute necessity for the production of red cells and hemoglobin in all vertebrates. Without copper the myelin sheath of the nerves, composed of phospholipids and cholesterol, permits the nerves to fail in their function of message carrying to the brain. The usual result is lack of coordination and eventually paralysis.

The liver is the principal storehouse of copper, although it has been found in every cell in the body. The lungs apparently store some copper for use as the activator of the enzyme, which aids in the oxygenation of iron in the blood. Also, a deficiency of copper often results in lungworm and other parasitic infections in animals. Then too, some animals become infertile. Others fail in the normal production of melanin and usually lose the dark coloring pigment in their hair. The wool fibers of sheep become stringy instead of curly. Alopecia and dermatitis occur in rabbits and cats. If the deficiency is severe anemia will occur in any mammal.

The blood of many invertebrates contains hemocyanin (a copper containing protein) instead of hemoglobin. Therefore, shellfish such as, abalone, clams conch, crabs, mussels, oysters, and shrimp are good sources of organic copper. Other sources are liver, spleen, lung, leafy vegetables, whole grains, peas, lentils, and nuts.

### Iodine

This organic mineral is an absolute necessity for the proper functioning of the thyroid gland. Over two thousand years ago the Greeks treated simple goiter by eating the ash of sponges, now known to be very rich in iodine. Even with this early start it is only within the last century that this condition has been recognized as a disturbance of iodine metabolism. Iodine is taken up by the thyroid gland and converted to diiodotyrosine and thyroxine.

Normally the uptake is in proportion to blood concentration. Absorption occurs most readily from the small intestine, but it is also absorbed by other mucous membranes including the skin and lungs. It is distributed as follows: 50 percent in the muscles, 20 percent in the thyroid gland, 18 percent in the skin, 6 percent in the skeleton, and the balance in the parotid gland, the spleen, and liver. While inorganic iodine is found in the blood it is the protein-bound iodine that is presumed to convey the circulating thyroid hormone.

New investigations emphasize the importance of naturally bound iodine. Iodine is involved as an essential catalyst in establishing calcium metabolism. Lack of iodine invariably shows up as a symptom in dental caries. In World War I this was demonstrated when examinees with iodine deficiency invariably had defective teeth. It is also involved in the proper metabolism of phosphorus and starches. Also, it has proven to be a factor in cretinism, obesity, slow sexual development, lowered vitality, in sexual frigidity and impotence, inability to think logically, loss of control of the mouth muscles with drooling and loss of tissue tone generally but especially so in the circulatory system.

The demand for iodine is greatest during puberty, pregnancy, menopause, in times of stress, or when infections occur. Normally the entire volume of blood iodine in the body is less than one milligram; however, it may be excreted through the liver, kidneys, skin, lungs, intestines, and also in mother's milk or saliva. Actually, a self-imposed iodine deficiency may occur in individuals who consume a heavy carbohydrate diet with little, if any, iodine-bearing foods and who overly void through any of the many excretory channels.

Agronomists advise that due to the solubility of iodine salts they have been leached out of the soil in some areas. According to published reports, areas of deficiency in this country have been listed as the Pacific Northwest, the Rocky Mountain area, the Central Plateau area, and the Great Lakes region. Food sources of iodine are shellfish, sea fish, sea animals, cod liver oil, sea vegetation such as dulse (sea lettuce), Irish moss, and kelp. Or any produce grown on soil having a good iodine content.

### Manganese

Manganese is essential to many reactions involved in the removal of the carboxyl groups. Therefore, it is the primary mineral component of the enzymes involved in the citric acid cycle or that part of metabolism involving the final oxidation of carbon dioxide. The first and most common disease found due to manganese deficiency was "perosis" in growing poultry. Perosis is commonly known as a slipped tendon characterized by a deformity of the tibia-metatarsal joint causing the tendon of the gastrocnemius muscle to slip from its normal position. Since the discovery of manganese deficiency in perosis, experiments with pigs, guinea pigs, heifers, rabbits, rats, and mice have revealed tendonitis and/or slipped tendon in various joints. In fact, it now has become quite common in humans, in specific joints, according to occupation.

Results in animal experiments revealed, according to Shils and McCollum, that the offspring of female manganese deficient rats are born prematurely dead, die soon after birth, suffer from lack of muscular coordination, loss of equilibrium, and poor growth. Boyer et al. found deficient rats to have poor growth, retardation of sexual maturity, infertility in the female, and sterility of the male. Amdure et al. found that skeletal deficiency of manganese such as in perosis was due to the decrease in bone phosphatase activity.

Although bony lesions are produced by manganese deficiency causing low phosphatase activity, its function in the growth of mammals is still being investigated. Even though manganese deficiency was the principal factor in these investigations, in some instances a lack of biotin, niacinamide, or choline also seemed to be involved.

In nature manganese accompanies iron everywhere. It is contained in the red blood corpuscles but in much smaller quantities than iron. However, like iron it is involved in carrying oxygen from the lungs to the cells. According to Carque, manganese enables the glands in general to improve the quality of their secretions. Food sources are "alfalfa, rye flour, raw oatmeal, barley, brown rice, wheat germ, wheat bran, dried peas, kidney beans, huckleberries, most nuts but especially black walnuts."

### Sulfur

In nature organic sulfur accumulates in plants in the stem and leaves, and in fruit in the skin and seeds. In our body it forms a part of the skin, hair, nails, tendons, and cartilage. Note that the sulfur containing parts have either softness, elasticity, or pliability. It is essential and of physiological importance in the anterior pituitary hormone, insulin, bile acid, thiamine, and glutathione.

Food sources are poultry, shellfish, salt water fish, mustard, egg yolks, tea, peanuts, and Brazil nuts. Protein foods containing the amino acids cystine and methionine are the most important source but, being heat labile, they are usually lost in food preparation. The accumulation of uric acid in the system is often caused by ingesting foods too rich in phosphorus and lacking sulfur. Raw fruits and vegetables (containing cystine and methionine) have been reported to counteract this excessive uric acid tendency.

### Silicon

Systemically organic silicon is found mostly in connective tissue (muscles containing about 2 percent). However, the pancreas contains the most, about 12 percent. Like sulfur it is found in hair, feathers, nails, and claws. Considered a safeguard in epidemic disease, it is effective as an antiseptic, preventative of chemical disintegration and putrefaction. With cellulose it combines to form the skin of fruits and vegetables and the outer coat of cereals. It combines with organic fluorine in the enamel of teeth.

Nature has placed silicon in the skin and walls of all cells where it acts as an insulator to prevent and retard too rapid radiation of the body heat and electrical energy. As a conductor it warms the blood and keeps the electrical energy flowing through its salty constituents. Both nerve substance and the albumin of the blood contain silicon, so it seems to act as the connecting link between the blood and the nerves. Apparently, many diseases of the blood and nervous system can be traced to a deficiency of silicon in the food as present-day processing destroys this indispensable element. Silicon deficiency has been reported to result in fatigue, dull hair and eyes, as well as flabbiness of both skin and muscles. Food sources are much like those for sulfur, with emphasis on raw fruits and vegetables.

### Cobalt

Cobalt is essential for the activity of certain enzymes. It is also an integral part of cyanocobalamin, a B12 molecule. The absorption of cobalt is dependent on the intrinsic factor in the gastric juices. When combined with certain proteins, B12 furnishes the extrinsic factor. Apparently, it affects a more complete utilization of iron in hemoglobin formation as a deficiency often results in anemia.

### Zinc

For a consideration of zinc, we refer you to *Applied Trophology*, Volume 11, No. 10, October 1967, entitled "Zinc, a Vital Micronutrient."

If further interested in chemical preservatives, we refer you to "Food Chemicals Criticized," as outlined in *Applied Trophology*, Volume 10, No. 5, May 1966.

> *"It's strange that man, the only creature that can reason, should be the very one that is unreasonable."*
>
> *—Country Parson*

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